Space Weather Technical Forecast

Issued on Saturday, 02 December 2023 at 01:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further G1-G2 Minor to Moderate storms expected at first, easing later day 1 (02 Dec). Chance of M-class flares (R1-R2 Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is at Moderate levels with the largest flare of the previous 24 hours an M1.1 flare peaking at 01/0439 UTC from AR3502 in the far northwest, a further M1.0 fare was recorded at 012120 UTC from AR3500. There are currently ten sunspot regions on the visible disc. Two new regions have emerged in a similar quadrant of the northwest disc in recent hours. The most westerly of the two regions has developed quickly and is now numbered AR3509 (Dao/Beta). AR3500 in the southwest remains the largest and most significant region, and there remains a weak delta spot signature in the north-eastern part of the group. The classification has been changed to Eki/Beta-Gamma-delta which reduces flare risk somewhat, accepted given recent signs of some slight stabilisation.

There are a large number of filaments on the Earth-facing disc. A filament lift off in the SE disk was observed around 01/1400 UTC, the resulting CME still awaiting full analysis but not expected to be Earth directed. A CME signature was observed in association with the most recent M1.0 flare from AR3500, we await data for analysis. Other CME signatures in coronagraph imagery during the past 24 hours are considered far-sided and thus not Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind speeds, as observed by ACE and DSCOVR at L1 began the period around 450 km/s (Slightly Elevated). This likely associated with the arrival of the CME from late 27 Nov. Speeds slowly declined to around 400km/s until 01/0850 UTC, when speeds suddenly increased to 500-560km/s (Elevated) as the CME from 28 Nov arrived at L1 and have persisted at Elevated levels.

Density was average to start, then rapidly increased to around 20 ppcc (Above Average) with the arrival of the first CME. Density then became Average to Below Average for a time, before increasing as the second CME arrived, becoming Above Average, peaking at 23 pppc at 01/1056 UTC, before slowly reducing during the remainder of the period.

The Interplanetary Magnetic Field (IMF), Bt, was Weak until the first CME arrived, when the Bt jumped to Moderate levels. A peak just above 15nT at 01/0125 UTC allowed the IMF to become briefly Strong. Following the arrival of the second CME, Bt increased to more persistently Strong levels, peaking at 28nT at 01/1004 UTC, and remaining erratically at Moderate to Strong levels into the period. The north-south component of the IMF (Bz), varied Weakly at first, then varied Moderately following the first CME. A stronger response was evident with the arrival of the second CME, becoming Strongly negative (peak -27nT at 01/1024 UTC) before easing to Weak or Moderately negative by the end of the period as the IMF underwent a slow rotation at L1 within the magnetic cloud. Phi angle was largely positive (away from the Sun) initially, becoming generally negative with the arrival of the second CME.

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Resultant Geomagnetic activity was Unsettled to Active (Kp3-4) between 01/0000-0900 UTC. Activity increased further to G3/Strong Storm levels 01/0900-1200 UTC, with further G1-G2 Minor to Moderate Storm intervals recorded 01/1200-1500, 1800-2100 and 2100-2400.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux was at Moderate levels (peak 394 pfu at 30/1915 UTC) but reduced to become Background following the arrival of the first CME at L1. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a steady then slightly declining trend. The observation at 01/0000 UTC was 1.39e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate with a chance of further isolated M-flares (R1-R2 Blackout), and a very slight chance of an isolated X-class flare (R3 Blackout). AR3500 in the southwest disc is most likely to be the source of any significant flares.

Solar Wind / Geomagnetic Activity: Geomagnetic activity and solar winds should slowly wane during the first 24 hours as current CME influence begins to ease, but with further G1-G2 Minor-Moderate Storm intervals expected at first and a slight chance of isolated further G3 Strong Storm intervals. Activity expected to become generally Quiet to Unsettled into day 2 (02 Dec) as winds return to background levels, remaining so until the arrival of the HSS later day 3 (04 Nov) or perhaps early day 4 (05 Dec) associated with the large CH76/- approaching the meridian. The onset of the HSS should see winds reach Elevated to Strong levels and geomagnetic activity increase to Active to G1-G2/Minor-Moderate Storm (Kp 4-6) levels for a time.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels. However, any significant flares, particularly from AR3500, or any notable filament eruptions will bring a chance of flux levels increasing, with a slight chance of approaching or perhaps exceeding the S1 Minor Radiation Storm level.

Electron flux has fallen to Background levels following the arrival of recent CMEs in the past 24 hours. Some recovery of flux to Moderate or High levels at diurnal peak is possible during day 2 (03 Dec), only to likely decrease to Background levels again as geomagnetic activity increases into day 3 and 4 (04-05 Dec) with the arrival of the HSS from CH76/-.

The associated 24 hour electron fluence is expected to remain below the Active threshold (1e8 integrated pfu). However, a rising trend is likely from day 2 onward, once any CME influence recedes with a slight chance of exceeding the Active threshold into day 3 (04 Dec).

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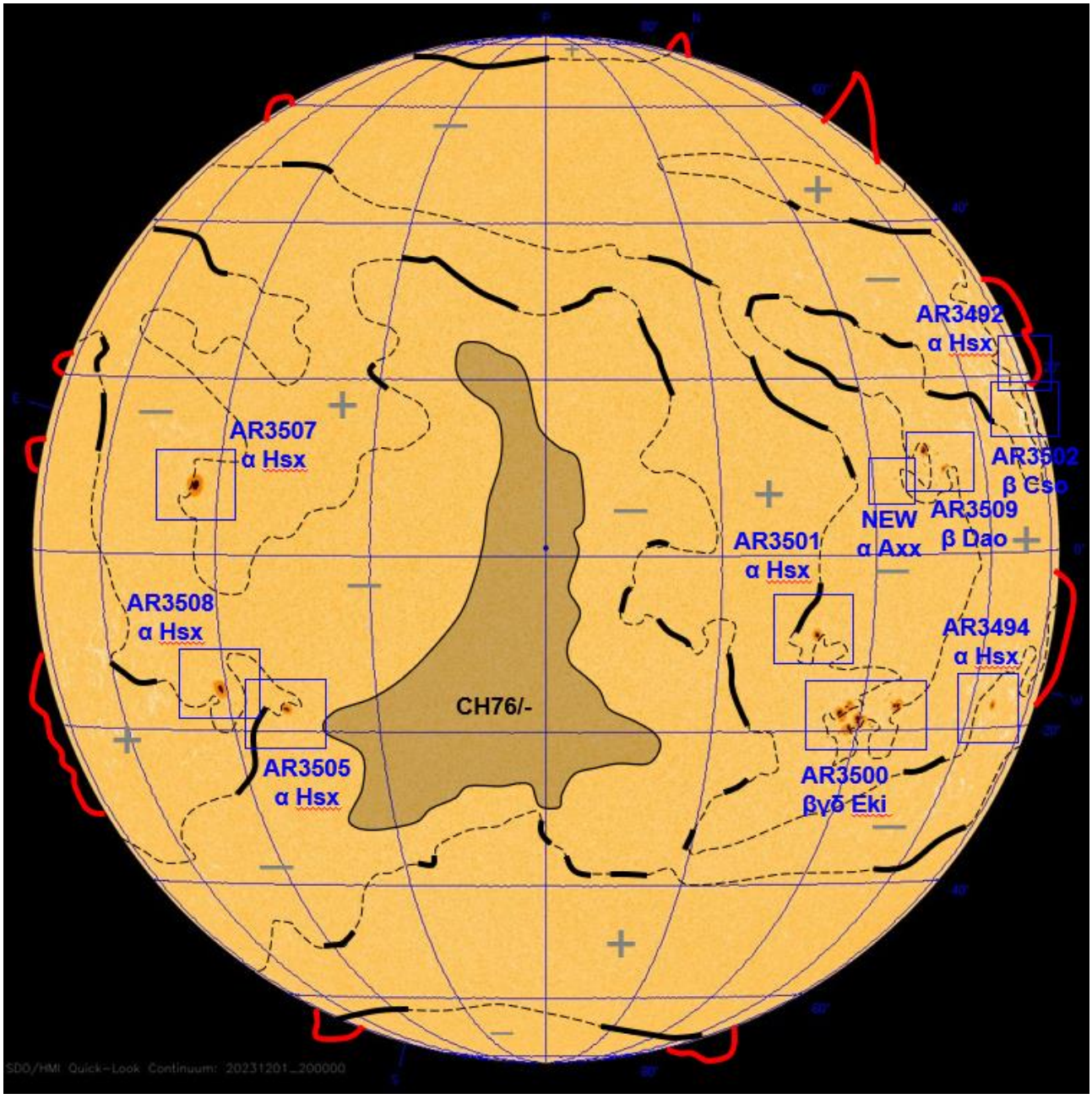
Figure 1. Solar Analysis Valid 01/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
No further CME arrivals are expected during the period and solar wind speeds and IMF strength are expected to ease in the next few days, however Geomagnetic activity is expected to be strongly influenced by this CME in the next 24 hours.

Current CME influence expected to slowly wane during day 1 (02 Dec), with solar winds expected to gradually reduce to Slightly Elevated or Background levels by day 2 (03 Dec). The next forecast enhancement is the arrival of a High Speed Stream (HSS) associated with the large CH76/- approaching the meridian. The expected onset of this feature is later day 3 (04 Dec) or perhaps early day 4 (05 Dec). CH76/- is a persistent feature, and is similar in size and position to the previous rotation, however during the previous rotation a CME arrival masked the initial influence of the coronal hole. Elevated to Strong winds of around 550-650km/s are expected though with slightly reduced confidence.

Geomagnetic activity should slowly wane during the first 24 hours, but with further G1-G2 Minor-Moderate Storm intervals expected at first and a slight chance of isolated further G3 Strong Storm intervals. Activity expected to become generally Quiet to Unsettled into day 2 (02 Dec), remaining at similar levels until the arrival of the HSS later day 3 (04 Nov) or perhaps early day 4 (05 Dec). The onset of the HSS should see activity increase to Active to G1-G2/Minor-Moderate Storm (Kp 4-6) levels before easing.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	80	5	60	30
Strong	G3	Yes	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Latest MOSWOC ENLIL output showing current CME influence easing and expected HSS into the period.

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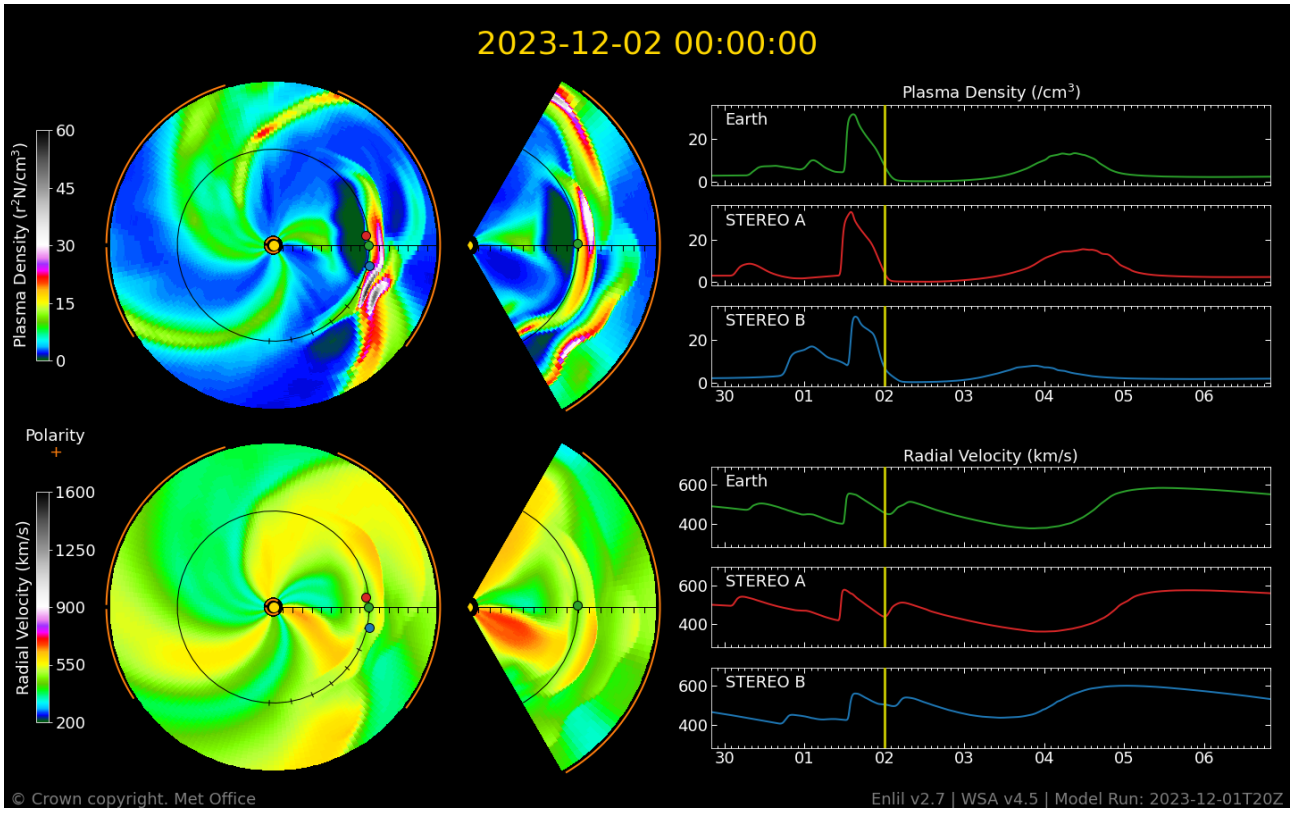
Space Weather Technical Forecast



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Met Office Space Weather Technical Forecast

Radio Blackouts - X-Ray Flares:
Solar activity is at Moderate levels with the largest flare of the previous 24 hours an M1.1 flare peaking at 01/0439 UTC from AR3502 in the far northwest, a further M1.0 fare was recorded at 012120 UTC from AR3500. Low to Moderate activity is expected to continue in the short term with a chance of further isolated M-flares (R1-R2 Blackout), and a very slight chance of an isolated X-class flare (R3 Blackout). The bulk of the current flare risk is attributed to AR3500 and this region will be approaching the limb by day 4 (05 Dec), however the active region AR3502 will depart the visible disk later into day 1 (02 Dec) resulting in a slight drop in risk. No significant oncoming regions suggested by far side data at this stage.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	40	35	35
Very Active	R3 to R5 X Class	No	5	5	5	5

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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background and expected to remain at this level. However, with the number of spots and filaments on the disc there is a chance of flux increasing in response to any significant flares or eruptions. The main risk is from AR3500, in the southwest disc. This was the source of an M9.8 flare late on 28 Nov, and while no proton response was observed at Earth on this occasion, any subsequent flares will also have the potential to increase the observed proton flux.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

Electron flux has fallen to Background levels following the arrival of recent CMEs in the past 24 hours. Some recovery of flux to Moderate or High levels at diurnal peak is possible during day 2 (03 Dec), only to likely decrease to Background levels again as geomagnetic activity increases into day 3 and 4 (04-05 Dec) with the arrival of the HSS from CH76/-.

The associated 24 hour electron fluence is expected to remain below the Active threshold (1e8 integrated pfu), as supported by REFM. However, a rising trend is likely from day 2 onward, once any CME influence recedes with a slight chance of exceeding the Active threshold into day 3 (04 Dec).

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	10	20	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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